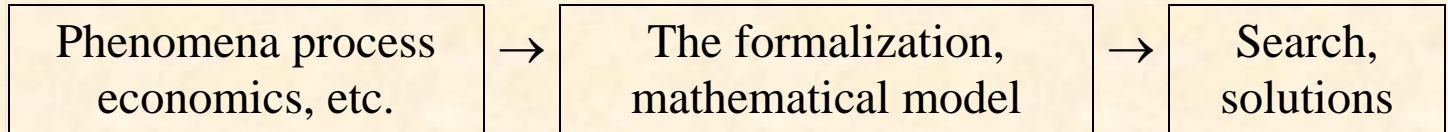


Theme 1. MATHEMATICAL MODELING. ALGORITHMS. PROGRAMMING LANGUAGES. SYSTEMS OF COMPUTER MATHEMATICS

Mathematical modeling

There are physical and mathematical models.

Mathematical model - a set of mathematical relations, equations, inequalities, describing the basic laws of the objects.



A mathematical model based on some simplifying (idealization) and is approximate descriptions of reality.

The criterion of adequacy (compliance) mathematical model and the real process is the practice (field experiments).

Analysis a mathematical model to predict the behavior of a real object.

There are mathematical models:

- linear or non-linear model;

- deterministic or stochastic;
- static or dynamic, and others.

Example. Mathematical model of the trajectory of the body:

$$x = t v \cos(\alpha), y = tv \sin(\alpha) - \frac{gt^2}{2}$$

Find:

$$t = \frac{x}{v \cos(\alpha)}; y = x \operatorname{tg}(\alpha) - \frac{x^2 g}{2v^2 \cos^2(\alpha)};$$

$$y = 0; x = \frac{v^2 \sin(2\alpha)}{g}$$

Simulation modeling (simulation) model provides representation in the form of an algorithm and a computer program that allows to reproduce the behavior of the object.

Simulation models are considered as computational experiments simulating the behavior of real objects.

Steps solution of the problem on the PC

1. **Setting objectives:** full content of the problem, its purpose solution.
2. **Mathematical model** solution of the problem: the description of the problem in mathematical terms, baseline data; output form of the results; accuracy of the solution of the problem.
3. **The method of solution** problem: the accuracy, speed and volume calculation; requirements to the capabilities of PCs and more.
4. **Algorithm development solution** tasks: establishing a logical sequence of operations (actions), recording and analysis algorithm.
5. **Writing program** language: the transfer algorithm on programming language.
6. **Debug programs:** Finding syntax and logic errors.
7. **Calculating experiment:** Settlement and analysis.

Algorithm - precise and clear sequence of actions (steps) that lead to solving the problem.

Requirements the algorithm:

- **mass** - is good for a whole class of similar problems.
- **specificity** (Certainty) - to exclude arbitrary interpretation.
- **effectiveness** - solution of a finite number of steps.

Block diagram of the algorithm records problem solution

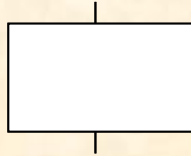
Molds recording algorithm, flowcharts, diagrams, verbal description.

Requirements to the flowchart algorithm:

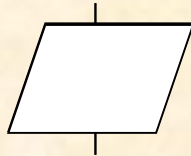
- the ratio of width to height graphics unit 3: 2;
- blocks need to fold the size of 5 units. (10, 15, 20, 25 ...)
- records can be used as a graphic in the middle part and outside using horizontal lines and brackets;
- Each block has one entry point.

Geometric notation and explanation algorithm blocks record

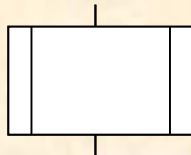
Process - performance computing actions



Input-output - input-output data



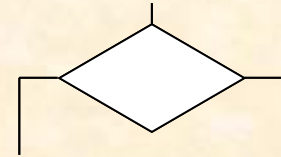
Defined process - implementation functions



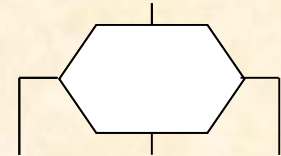
Connector - break flow lines



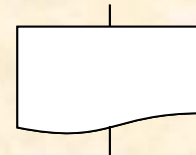
Solution - test conditions



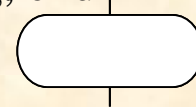
Modification - the beginning of the cycle



Document - IO results

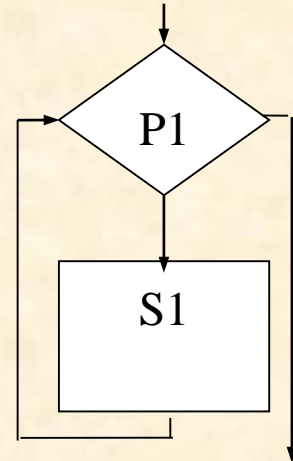
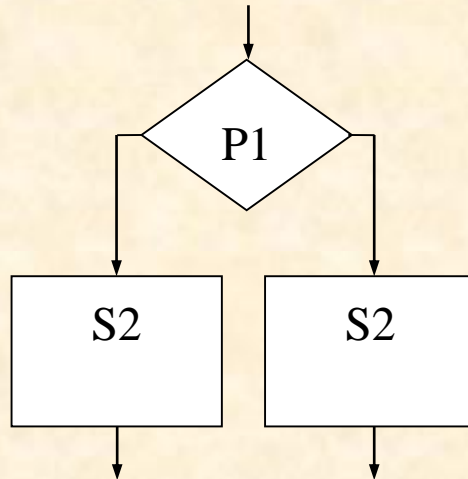
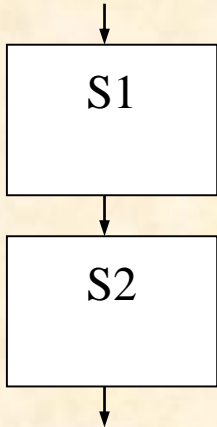


The beginning, end



Basic algorithmic structures:

- **linear** - consists of successive actions;
- **condition** - sequence execution depends on certain conditions;
- **cyclic** - one and the same sequence is performed two or more times.



Languages and programming environment

programming Languages - a system of symbols for accurate recording algorithm, which is understandable for the PC.

Programming languages much like ordinary language - English or Ukrainian and consist of words, phrases, syntax. Write a program - an algorithm to translate a programming language, receptive PC. The same algorithm can be translated into different languages of programming.

Programming languages are divided into:

- **algorithmic** (Procedural) - language describing the algorithm for solving the problem using the list of procedures, for example, Basic, Pascal, C, Logo and others;
- **functional** - description of the domain model means the hierarchy of functions, such as language Lisp;
- **logical** - description of the domain model by means of mathematical logic, such as language Prolog, SmallTalk.

Programming can be divided into:

- **visual** Programming - tools to help you quickly create an application by visual design its layout in graphical form, for example, Visual C, Visual Basic, Delphi.
- high-level language - consisting of operators, similar to normal speech;
- low level language (assembler) - converts human-characters (mnemonics) into machine code.

Translation from programming language into machine code carried translators - automated translations.

Two variants of translation:

- **compiler** - translate the program, after which it runs;
- **interpreter** - translate parts of the program (the line) and immediately executes.

C language and its environment

C. It was established in 1972, Denis Ritchie to develop the operating system UNIX.

In the C language developed graphic system AutoCAD, etc. Windows OS shell.

Programming system (Platform, integrated environment, IDE) - a set of hardware and software that implements the ability to record programming language operators and their debugging, compilation and execution.

Object-oriented programming (OOP)

OOP - a method of programming that can be considered conceptual model as a set of objects.

OOP implemented in Visual C ++, Delphi and other media.

The basis of the OOP put a new object (data type) - class.

The basic terms of the PLO:

- **Encapsulation** (*encapsulation*) - way to combine data and functions (methods) into a single structure. In C ++ classes for controlling functional elements of object descriptors used by private, public, protected.
- **The hierarchy of classes.** Objects that are based on the description of the class, called instances (instance) class. You can build a hierarchy of classes, which consist of a base class parents (parent) and several classes of descendants (child).
- **Imitation** (*inheritance*) - the ability to follow class features of other classes.
- **Polymorphism** (*polimorphism*) - OOP concept in which the same message, you can send the parent class and derived classes objects.

Systems of computer mathematics

Systems of computer mathematics (SCM) replace the work of mathematicians - theoreticians and analysts a high level.

There discoveries made using such systems.

The term "computer mathematics" includes a set of theoretical and methodological tools and modern software and hardware to allow all mathematical calculations with high accuracy and performance, build complex computational algorithms chain with strong visualization and process data at their processing.

All SCM can be divided into two groups:

1. for numerical computations - Eureka, MathCAD, MatLAB, Excel;
2. Symbolic Computation - Maple, MuPAD, Derive, Mathematica.

Each of these characteristics SCM internal structure and implementation of the interface.

Arithmetic system MathCAD

MathCAD - SCM solution to automate conventional mathematical problems in various fields of science, technology and learning.

MathCAD name comes from the words: MATHematic (mathematics) and CAD (Computer Aided Design - computer-aided design). Developer - MathSoft Inc (<http://www.mathsoft.com>).

Today used MathCAD 15. Price about \$ 800.

The system:

- **editor** documents - enter text, formulas, graphs etc.
- *MathConex* - integrator with other systems;
- **background** System - thematic and indexed directory assistance;
- **fast crib** - short examples with minimal commentary.

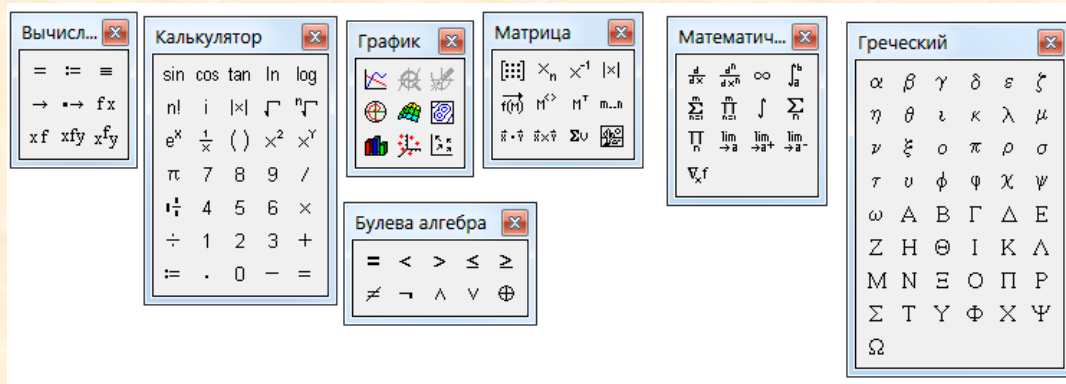
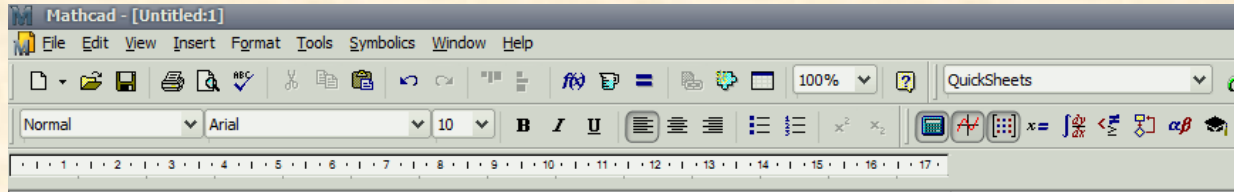
The calculation in MathCAD can be done in one of three ways:

- choice of menu operation;
- The toolbar;

- appeal to the relevant functions.

Document MathCAD called WorkSheets (working sheets) combines the code written in a visually-oriented language that is not very different from the usual language of mathematics.

interface MathCAD - a set of tools that provide the control system MathCAD via keyboard and mouse.



System engineering calculations MatLAB

MatLAB (Short MATrix LABoratory - Laboratory matrices) is an interactive system for use engineering and scientific computing with a focus on working with data sets.

Created by MatLAB MathWork Inc (<http://www.mathwork.com> USA). Widely used began in the late 80s after the launch of MatLAB 4.0. Price about \$ 2,940.

The main application areas MatLAB - mathematical calculations, data analysis and visualization, digital signal processing and image management systems design, application development.

Built-in universal interfaces allow integration procedures in languages C, Java and others.

The system differs from other similar by:

- purpose engineering calculations;
- used programming language similar to BASIC;
- ease of integration with other systems.

System Research Mathematica

Mathematica- the company Wolfram Research, Inc. (<http://www.wolfram.com/>) Has a broad set of tools that translate complex mathematical algorithms in the program. Price - about \$ 1,460.

Mathematica 1 (1988). Became the first computer algebra system which caused interest from engineers and scientists.

All algorithms are aware of institutions of higher mathematics inherent in the environment of *Mathematica*.

Shortcomings *Mathematica*: poorly understood functional programming language system, unusual fixation input keys Shift + Enter (usually fixed input Enter), the unusual names of functions, such as Sin [x].

Advantages *Mathematica*: the presence of dynamic variables, interactive interface speed computing capabilities through the support of modern multicore processors.

Symbolic algebra system Maple

Maple Created by a group of symbolic computation, an outstanding mathematician Gonay organized in 1980 at the University of Waterloo, Canada. The latest version is Maple 18 Maple 2017. Price - about \$ 3,000.

Maple - a Computer Algebraic System (CAS - Computer Algebra System), which means its action under the laws of algebra in sections Calculation, differential equations and linear algebra and others.

The system has absorbed most of mathematical functions and rules of transformation that is in mathematics.

Maple used for solving aerodynamics, field theory, thermal conductivity, theoretical mechanics and others.

Maple kernel used in the system MathCAD, MatLAB.

Maple system combines:

- programming language (the language of interactivity with the system);
- Editor for the preparation and editing of documents and programs;

- Modern multi-window user interface;
- powerful help system with many thousands of examples;
- core algorithms and mathematical expressions transformation rules;
- library of built-in functions (over 3000 for Maple 6) and others.

Maple is a powerful programming system that includes speech:

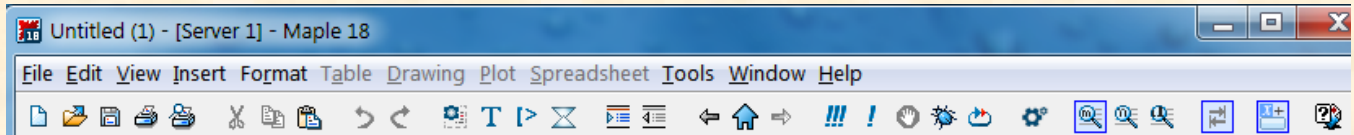
- **input**- used to set matters (input for processing). This type of interpreting it and has a large number of defined mathematical and graphical functions.
- **implementation**- C-language. This language is implemented kernel.
- **programming**- Maple-language. This language has a traditional means for solving common programming tasks on the basis of structural approach: loops, conditional and unconditional transitions, logical operators, procedures, etc.

Most of the library functions designed to Maple-language that allows users to supplement or modify them.

The system interface and work interactively

Maple system has a standard graphical user interface for applications running Windows.

The files include documents full text of the program, the results of calculation, graphical information and more.



When you download the program on the screen is displayed. At the top, directly under the window is main menu:

- **File** - work with files and print documents;
- **Edit** - document editing commands;
- **View** - type of control interface;
- **Insert** - insertion operations;
- **Format** - Operations task formats;
- **Spreadsheet** - Operations task tables;

- **Options** - tasks and change system parameters;
- **Window** - managing windows;
- **Help** - Work with the Help system.

Working in interactive mode

Worksheet consists of the input area and output area.

Dialogue with the system Maple happens in questions: the user enters commands and pressing [Enter] sends them to perform core system Maple. The result of the team appears in the output.

To enter a formula in the standard mathematical form should run Insert -Math Input. In the input field will be displayed in the form of command syntax Maple, and in removing this same team will be reflected in mathematical notation.

Entering text comments - a mode in which any information is understood as a text (non-complying). To insert text comments should be run Insert -Text or click on the main toolbar or F5.

In Maple 18 introduced a toolbar button that duplicates the menu command Edit -Execute -Worksheet (Run the entire page).!!!

The main elements of syntax Maple:

- /flashing inclined line - token entry formula.
- | flashing vertical line - input marker.
- ; fixation mark the end of the expression output results on screen.
- : fixation mark the end of the expression, which prevents the output result.
- = assignment operator (eg, $x := 4$).
- = equality operator to specify the identities and logical conditions ($a = b$), variable regions ($i = 1..5$) and values of options ($color = black$).

Moving to a new line command (without execution) by pressing the key combination [Shift + Enter].

To insert a new row: top Ctrl + Shift + K; Bottom Ctrl + Shift + J.

Basic editing operations are in the main menu Edit.

- *delete* Ctrl + Del - Erase selected objects.
- *Find ...* or Ctrl + F5 - find text or mathematical formula.
- *Input Mode* or F5 - on / off input text.

Maple worksheets are stored in files with the extension mw.

It is possible to save the worksheet files in other formats, indicating the Save As dialog command of the format, or use the commands submenu Export As:

- *Plain Text .txt* - plain text file.
- *Maple Text .txt* - Text Format Maple.
- *RTF.rtf* - format RTF (pasting worksheets in MS Word documents preserving color palette).